Research Brief for
DOE/IHEA Process Heating Materials Forum

Research Title: Advanced Refractory Materials Research Program, DOE Albany Research Center

Industry Need: Refractories are a special class of ceramic materials that, because of their unique capability to insulate and contain harsh, high-temperature, corrosive and erosive environments, are used in containment and protection systems in a wide variety of industrial heating processes. Although refractories are not typically high-profile elements in any industrial process, their in-service performance can nonetheless play a pivotal role in determining the efficiency, reliability and economics of production. Improvements in refractory material performance often translate directly into longer continuous runs and reduced materials and energy costs, resulting in an increase in the reliability, availability, and maintainability of the process.

Existing Research: At the Albany Research Center we focus on enhancing energy and process efficiency, and reducing environmental impact, through the design of improved refractory materials and the development of improved industrial practices. Our project on the development of high-performance refractory containment and protection materials for slagging gasifiers, seeks to develop improved materials with a service life that is at least double that which is currently available to the industry. Current generation refractory and thermocouple protection materials used in slagging gasifiers have unacceptably short service lives, severely limiting the reliability and cost-effectiveness of gasification as a means to generate power. Through cooperative research and development agreements with gasifier manufacturers and operators, we have identified the principal causes of material failure in the slagging gasifier environment, and produced a material that is designed to better resist such failures. This new material (patent pending) exhibits significantly improved performance in laboratory exposure tests. In collaboration with a commercial refractories manufacturer, we have scaled up production of this material using commercial processing methods, and are currently in the midst of an expanded series of static and dynamic tests to confirm material performance. It is our intention to install test panels of our improved refractory in several commercial slagging gasifiers in the late spring of 2003. Another example of ARC refractories research is a recently concluded four-year effort to develop improved operating procedures for the steelmaking industry to enhance refractory life and reduce energy consumption in electric arc furnaces. This project involved members of the Steel Manufacturers Association as well as commercial refractory producers. The slag chemistry and slag foaming models developed in this project have resulted in a significant decrease in energy costs and an increase in refractory life in the commercial operations in which they have been deployed.

Proposed Activity: The IHEA has identified improved service life for both refractories and sensor protection materials as specific areas that need improvement. Our proposed solution to these needs would follow the common-sense model that we have successfully

used with the gasifier industry: identify the specific materials challenges that are limiting service life and design a refractory material that is more resistant to those challenges. This approach includes *in-situ* and *post-mortem* analyses of spent materials to identify failure mechanisms, as well as conversations with equipment manufacturers and operators to define the specific conditions of the operating environment. Newly engineered materials are subjected to laboratory exposure tests, with the more promising materials optimized for the specific application. Production of the improved materials are scaled to a commercial setting with the collaboration of refractories manufacturers, and the materials are subjected to an expanded battery of tests, including the placement of test panels in commercial systems. Throughout this process, the development of improved materials that are both economic and effective is a top priority.

Lead Scientists: The refractories group at the Albany Research Center consists of five professionals, in addition to support staff, and is led by Mr. James Bennett and Dr. Cindy Dogan.

James Bennett is a ceramic engineer who has worked in the refractory industry for over 30 years. He graduated from Clemson University with a BS in Ceramic Engineering and from Georgia Institute of Technology with a MS in Ceramic Engineering. He has worked for a refractory producer, a recycler of aluminum metal, a flat glass processor, and for the federal government, authoring/coauthoring over 50 publications. He is currently the Chairman of the Refractories Division of the American Ceramic Society. James can be reached by telephone at the Albany Research Center at 541-967-5983, or by email at bennett@alrc.doe.gov.

Cynthia Powell Dogan is a materials research engineer, with more than a decade of research experience in the area of high-temperature phase and microstructural development in ceramic materials and the effect of these phase changes on the mechanical properties of the material. She has written more than 40 technical publications in these areas, including the paper, “Improving Refractory Service Life in Slagging Coal Gasifiers,” which was recognized for technical merit at the 2001 International Pittsburgh Coal Conference in Newcastle, Australia. She received her Ph.D. in Materials Science from Case Western Reserve University and her M.S. and B.S. in Ceramic Engineering from Clemson University. Cindy can be reached by telephone at the Albany Research Center at 541-967-5803, or by email at dogan@alrc.doe.gov.